

# EFFICACY OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION & MANUAL STRETCHING INTEGRATED WITH CONVENTIONAL EXERCISES IN OBESE PATIENTS (CLASS-I) WITH PLANTAR FASCIITIS

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## Abstract :

**Background:** Plantar fasciitis is a common musculoskeletal condition associated with heel pain, reduced ankle mobility, impaired balance and functional limitations. Obesity may increase plantar loading and contribute to biomechanical dysfunction. An integrated programme combining proprioceptive neuromuscular facilitation (PNF), manual stretching and conventional exercises may address pain, flexibility, strength, proprioception and functional performance.

**Aim:** To study the effect of proprioceptive neuromuscular facilitation and manual stretching integrated with conventional exercises in obese individuals (Class-I) with plantar fasciitis.

**Material and Method:** A single-group pre-post experimental study was conducted among 21 obese adults (Class-I), aged 18-40 years, with chronic plantar fasciitis. Participants received ankle PNF, manual stretching and conventional exercises for four weeks, three sessions per week. Outcomes were assessed before and after intervention using the Visual Analogue Scale (VAS), Foot Functional Index (FFI), Windlass Test, Weight-Bearing Lunge Test (WBLT), Functional Reach Test (FRT) and Body Mass Index (BMI). Within-group changes were analysed using the Wilcoxon signed-rank test, while the exact McNemar test was used for the categorical Windlass Test.

**Results:** VAS decreased from  $7.95 \pm 0.74$  to  $3.43 \pm 1.60$  ( $p = 0.000102$ ), while FFI decreased from  $70.86 \pm 4.57$  to  $34.33 \pm 12.84$  ( $p = 0.000130$ ). WBLT increased from  $6.50 \pm 0.58$  cm to  $9.52 \pm 1.23$  cm ( $p = 0.000131$ ), and FRT increased from  $22.24 \pm 1.22$  cm to  $29.15 \pm 3.07$  cm ( $p = 0.000127$ ). The reported effect size was  $r = 0.877$  for all four continuous outcomes. The Windlass Test changed from positive in all 21 participants before intervention to positive in 7 participants after intervention ( $p = 0.000122$ ).

**Conclusion:** The four-week integrated programme was associated with significant improvements in pain, foot-related function, ankle dorsiflexion-related mobility and functional balance, with a significant shift in Windlass Test status. The findings support the potential clinical usefulness of combining PNF, manual stretching and conventional exercises in obese individuals with plantar fasciitis.

**Index Terms:** Plantar fasciitis, Proprioceptive Neuromuscular Facilitation, manual stretching, conventional exercises, obesity, dynamic balance.

## I. INTRODUCTION

Plantar fasciitis is characterized by pain and dysfunction involving the plantar fascia, a thick connective tissue structure originating at the calcaneal tuberosity. The plantar fascia contributes to shock absorption and force distribution during foot strike. Persistent mechanical stress, repetitive microtrauma and tensile loading can compromise foot function and contribute to altered lower-limb biomechanics.

Pain associated with plantar fasciitis may produce compensatory gait patterns, while weakness of the plantar flexors, toe flexors and intrinsic foot musculature may further affect dynamic stability. Hip muscle weakness, reduced medial longitudinal arch support and excessive foot pronation can also contribute to increased plantar fascia stress. In the Asia-Pacific classification used in the thesis,  $BMI \geq 25$  kg/m<sup>2</sup> is considered obese.

Proprioceptive Neuromuscular Facilitation is a neuromuscular approach intended to improve coordinated movement, muscle activation and joint position sense. Three-dimensional ankle patterns and combined isotonic techniques may enhance ankle control and functional stability. Manual stretching, particularly of the gastrocnemius, soleus and plantar fascia, aims to reduce tissue tension and improve ankle dorsiflexion and fascial extensibility.

Conventional exercises such as toe curls, resisted ankle movements, short-foot exercises, heel raises and balance training can strengthen intrinsic and extrinsic foot musculature and improve functional control. An integrated intervention combining PNF, manual stretching and conventional exercises may therefore address several contributing factors simultaneously.

The need for the present study arose from the limited evidence on an integrated PNF and stretching programme combined with conventional exercises in obese individuals with chronic plantar fasciitis, particularly with respect to pain, foot function, ankle mobility and functional balance.

## II. AIM AND OBJECTIVES

**Aim:** To study the effect of proprioceptive neuromuscular facilitation and manual stretching integrated with conventional exercises in obese individuals (Class-I) with plantar fasciitis.

**Objectives:** (1) To examine the effect of stretching exercises on ankle dorsiflexion range and its relationship with functional balance. (2) To determine whether combining stretching and muscle strengthening improves clinical and functional outcomes. (3) To determine the effect of intrinsic and extrinsic foot muscle strengthening on balance and lower-limb functional alignment. (4) To examine the role of proprioception-focused rehabilitation using PNF in improving ankle biomechanics and functional performance.

## III. MATERIALS AND METHODS

| Parameter        | Description                                             |
|------------------|---------------------------------------------------------|
| Study type       | Experimental study                                      |
| Study design     | Single-group pre-post intervention                      |
| Sampling         | Consecutive sampling                                    |
| Study population | Obese adults (Class-I), Asia-Pacific BMI classification |
| Study duration   | 4 months                                                |
| Study setting    | Sangli city                                             |
| Sample size      | 21 participants                                         |
| Age              | 18–40 years                                             |

Participants were eligible if they were male or female adults aged 18–35 years with obesity (Class-I), clinically diagnosed chronic plantar fasciitis of at least 12 weeks' duration, a VAS score  $\geq 6$ , pain during the first steps in the morning and tenderness at the medial calcaneal tubercle, with independent ambulation and willingness to attend three sessions per week. Exclusion criteria included non-plantar-fascia causes of heel pain, previous relevant foot/ankle surgery, systemic inflammatory conditions affecting the foot, corticosteroid injection, neurological or vascular pathology affecting gait, pregnancy and concurrent musculoskeletal disorders that could confound outcomes.

Ethical clearance was obtained before participant recruitment. The study procedure was explained in the participant's vernacular language and written informed consent was obtained. Pre-intervention assessment was followed by four weeks of intervention and post-intervention reassessment.

### III.A. INTERVENTION PROTOCOL

Group A received PNF, manual stretching and conventional exercises. Ankle PNF included rhythmic initiation and combined isotonic techniques using three-dimensional D1 and D2 patterns. D1 flexion involved dorsiflexion, inversion and toe extension; D1 extension involved plantarflexion, eversion and toe flexion; D2 flexion involved dorsiflexion, eversion and toe extension; and D2 extension involved dorsiflexion, inversion and toe flexion. The dosage was 3 sets of 10 repetitions per movement direction, with each repetition held for 5 seconds and 10 seconds rest, for approximately 15 minutes.

Manual stretching included hamstring stretching using supine straight-leg raise, gastrocnemius and soleus stretching using standing lunge positions, and plantar fascia stretching by manually dorsiflexing the toes. The documented dosage was 3 sets with a 30-second hold per stretch.

Conventional exercises included toe curls (3 × 10 repetitions), resisted ankle dorsiflexion, plantarflexion, inversion and eversion with Theraband (3 × 10), short-foot/foot-doming exercises (3 × 10 with 5-second hold), double-leg heel raises (3 × 10), single-leg stance and Star Excursion Balance Test drills in three directions. Balance and functional training was performed for approximately 10–15 minutes. The home programme included isometric contractions and short-foot exercises twice daily for 10 minutes.

### III.B. OUTCOME MEASURES AND STATISTICAL ANALYSIS

Pain intensity was assessed using the Visual Analogue Scale (VAS), a 10-cm scale from 0 (no pain) to 10 (worst possible pain). Foot-related pain, disability and activity limitation were assessed using the Foot Functional Index (FFI), expressed as a percentage. The Windlass Test was used as a clinical test for plantar fasciitis, with reproduction of medial calcaneal heel pain considered positive. WBLT measured the distance between the foot and wall while maintaining heel contact during forward lunge. FRT measured the maximal forward reach distance without moving the feet. BMI was calculated from body weight and height.

Statistical analysis was based on the supplied thesis dataset. Pre- and post-intervention continuous outcomes were compared using the paired Wilcoxon signed-rank test. The exact McNemar test was used for the categorical Windlass Test. Statistical significance was considered at  $p < 0.05$ .

### IV. RESULTS

Twenty-one participants were included. The mean age was  $28.95 \pm 4.38$  years and the mean BMI was  $27.82 \pm 1.81$  kg/m<sup>2</sup>. Females constituted 14 participants (66.7%) and males 7 participants (33.3%).

| Gender | Frequency | Percentage |
|--------|-----------|------------|
| Female | 14        | 66.7%      |
| Male   | 7         | 33.3%      |
| Total  | 21        | 100.0%     |

| Outcome   | Pre-intervention Mean<br>± SD | Post-intervention<br>Mean ± SD | Mean change |
|-----------|-------------------------------|--------------------------------|-------------|
| VAS       | $7.95 \pm 0.74$               | $3.43 \pm 1.60$                | −4.52       |
| FFI       | $70.86 \pm 4.57$              | $34.33 \pm 12.84$              | −36.52      |
| WBLT (cm) | $6.50 \pm 0.58$               | $9.52 \pm 1.23$                | +3.02       |
| FRT (cm)  | $22.24 \pm 1.22$              | $29.15 \pm 3.07$               | +6.91       |

Table 2. Pre- and post-intervention descriptive statistics.

| Outcome | Wilcoxon W | z-value | p-value  | Effect size (r) |
|---------|------------|---------|----------|-----------------|
| VAS     | 0.00       | −3.823  | 0.000102 | 0.877           |
| FFI     | 0.00       | −3.823  | 0.000130 | 0.877           |
| WBLT    | 0.00       | +3.823  | 0.000131 | 0.877           |
| FRT     | 0.00       | +3.823  | 0.000127 | 0.877           |

All four continuous outcomes demonstrated very highly significant pre- to post-intervention changes ( $p < 0.001$ ), with a reported very large effect size ( $r = 0.877$ ).

| Windlass Test status | Pre-intervention | Post-intervention |
|----------------------|------------------|-------------------|
| Positive             | 21 (100.0%)      | 7 (33.3%)         |
| Negative             | 0 (0.0%)         | 14 (66.7%)        |
| Total                | 21 (100.0%)      | 21 (100.0%)       |

The exact McNemar test demonstrated a very highly significant change in Windlass Test status ( $p = 0.000122$ ), with 14 participants changing from positive to negative after intervention.

### V. DISCUSSION

The present study evaluated the effect of an integrated programme of PNF, manual stretching and conventional exercises in 21 obese adults with chronic plantar fasciitis. The sample contained a greater

proportion of females (66.7%) than males (33.3%). The overall findings demonstrated significant improvement in pain, foot function, ankle mobility and functional balance after four weeks of intervention. Pain intensity showed a substantial reduction, with mean VAS decreasing from 7.95 to 3.43. This finding suggests that the combined programme may have reduced mechanical and neuromuscular contributors to heel pain. The improvement is consistent with the literature reviewed in the thesis, where stretching and strengthening programmes were reported to improve pain and function in plantar fasciitis. Studies of PNF-based rehabilitation have also reported beneficial effects on pain, ankle mobility, proprioception and balance.

FFI decreased from 70.86 to 34.33, indicating marked improvement in foot-related pain, disability and activity limitation. The inclusion of intrinsic and extrinsic foot strengthening, plantar fascia and calf stretching, and PNF may have addressed both local tissue flexibility and neuromuscular control. Previous work comparing stretching with foot and hip strengthening has suggested that strengthening can provide additional functional stability beyond stretching alone.

WBLT increased from 6.50 cm to 9.52 cm, indicating improved weight-bearing ankle mobility. Restricted dorsiflexion has been identified as an important biomechanical factor in plantar heel pain, and the present protocol directly targeted gastrocnemius, soleus and plantar fascia flexibility. FRT increased from 22.24 cm to 29.15 cm, suggesting improved functional balance. The PNF patterns, short-foot exercises, heel raises and balance training may have contributed to improved neuromuscular control and postural stability.

The Windlass Test further supported the clinical improvement. Before intervention, all 21 participants were positive; after intervention, 14 participants became negative and only 7 remained positive. This significant categorical change indicates an overall reduction in provoked heel pain during the test.

Although the response was favourable overall, individual variation was present, including three participants with no measurable improvement as reported in the thesis. Differences in symptom severity and duration, BMI, activity level, adherence and individual biomechanical characteristics may have contributed to variation in response. Because the study used a single-group pre-post design without a control group, the improvements cannot be attributed exclusively to any one component of the combined intervention.

## VI. LIMITATIONS AND FUTURE RECOMMENDATIONS

- The sample size was small ( $n = 21$ ), which limits generalizability.
- The study did not include a separate control group.
- No follow-up assessment was performed to determine long-term retention of treatment effects.
- The relative contribution of PNF, manual stretching and conventional exercises could not be determined because all interventions were delivered together.
- Future studies should use larger samples, controlled or randomized designs, longer intervention periods and follow-up assessments, and should examine adherence and other relevant biomechanical outcomes.

## VII. CONCLUSION

A four-week integrated programme of proprioceptive neuromuscular facilitation, manual stretching and conventional exercises was associated with significant improvements in pain, foot-related function, weight-bearing ankle mobility and functional balance in obese individuals with chronic plantar fasciitis. The significant improvement in Windlass Test status further supports a favourable clinical response. These findings suggest that a multimodal physiotherapy programme addressing flexibility, strength, proprioception and functional control may be useful in the management of plantar fasciitis in obese adults. Further controlled studies are required to establish the independent and combined effects of each intervention component.

## VIII. CLINICAL IMPLICATIONS

The findings support the use of an integrated physiotherapy approach for obese individuals with plantar fasciitis. Clinicians may consider combining PNF-based ankle neuromuscular training, plantar fascia and calf stretching, intrinsic and extrinsic foot strengthening, heel raises and balance exercises rather than relying on a single treatment component.

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